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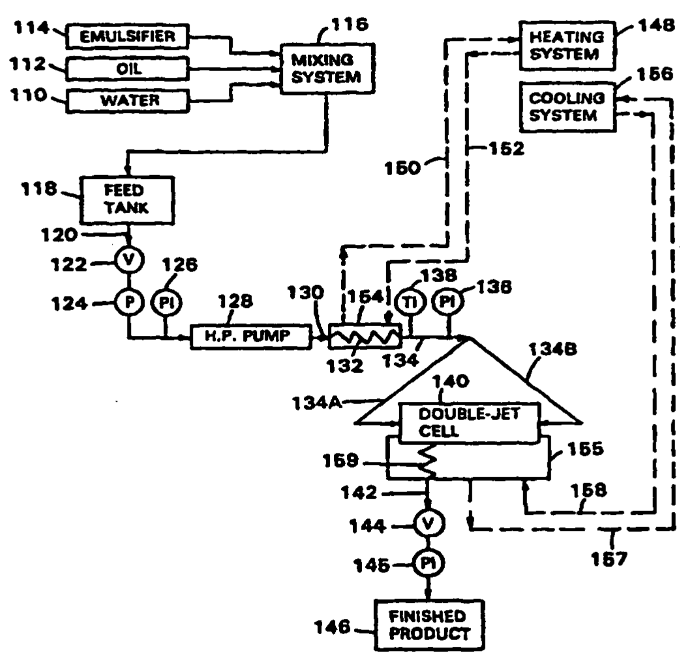
(54) Title: PROCESSING PRODUCT COMPONENTS

(57) Abstract

Methods and apparatuses for processing product components. The methods include directing a first jet of fluid along a first path and directing a second jet of fluid along a second path to cause interaction between the jets that forms a stream oriented essentially opposite to one of the jet paths.



PROCESSING PRODUCT COMPONENTS

Background of the Invention

This invention relates to processing product components.

Product components can be intermixed to produce a wide variety of products having different physical characteristics. For example, a colloidal system may be a stable system comprising two immiscible substance phases with one phase dispersed as small droplets or particles in the other phase. Colloids may be classified according to the original phases of their constituents. For example, a solid dispersed in a liquid may be a dispersion. A semisolid colloidal system may be a gel. An emulsion may include one liquid dispersed in another.

For simplicity, we will call the dispersed phase "oil" and the continuous phase "water", although the actual product components may vary widely. Additional components may be included in a product such as emulsifying agents, known as emulsifiers or surfactants, that can stabilize emulsions and facilitate their formation by surrounding the oil phase droplets and separating them from the water phase.

As is described in U.S. Patent No. 5,720,551, incorporated in its entirety, high pressure homogenizers are often used to intermix product components using shear, impact, and cavitation forces in a small zone. To prevent rapid wear to a high pressure homogenizer caused by different materials (e.g., relatively large solids), product components may be preprocessed by equipment such as ball mills and roll mills to reduce the size of such materials.

In general, in another aspect, a method of processing product components includes directing a first jet of fluid formed from a common fluid source along a first path and directing a second jet of fluid formed from the common fluid source along a second path essentially opposite to the first path. The jets have different velocities and cause sheer and cavitation in a third fluid positioned between the jets. The jets form a stream oriented opposite one of the paths.

In general, in another embodiment, an apparatus for processing product components includes two nozzles configured to deliver jets of fluid along two different paths, and an elongated chamber that contains an interaction region in which the two paths meet. The chamber is configured to form a stream of fluid from the two jets that follows a path that has essentially the opposite direction from one of the paths of one of the jets.

Embodiments may include one or more of the following features. The apparatus may also include an outlet port configured to emit the stream. The nozzles may be aligned essentially opposite one another. The apparatus may also include an inlet port configured for receiving a second fluid. The inlet port may be aligned to position the second fluid such that the jets cause sheer and cavitation in the second fluid. The apparatus may also include a port that may be configured to be either an inlet port or an outlet port.

The chamber may include one or more reactors which may have different characteristics (e.g., inner diameter, contour, and composition). Seals may be positioned between the reactors. The seals may have different seal characteristics (e.g., inner diameter).

In general, in another aspect, an apparatus for processing product components includes two nozzles,

injecting compressed air or nitrogen, and/or by rapid heat exchange, while the emulsion is subjected to sufficient turbulence to overcome the oil droplets' attractive forces and maintaining sufficient pressure to prevent the water from vaporizing.

Scale-up procedures from small laboratory scale devices to large production scale systems is made simpler because process parameters can be carefully controlled. The invention is applicable to colloids, emulsions, microemulsions, dispersions, liposomes, and cell rupture. A wide variety of immiscible liquids may be used in a wide range of ratios. Smaller amounts of (in some cases no) emulsifiers are required. The reproducibility of the process is improved. A wide variety of products may produced for diverse uses such as food, beverages, pharmaceuticals, paints, inks, toners, fuels, magnetic media, and cosmetics. The apparatus is easy to assemble, disassemble, clean, and maintain. The process may be used with fluids of high viscosity, high solid content, and fluids which are abrasive and corrosive.

The emulsification effect continues long enough for surfactants to react with newly formed oil droplets. Multiple stages of cavitation assure complete use of the surfactant with virtually no waste in the form of micelles. Multiple ports along the process stream may be used for cooling by injecting components at lower temperature. VOC (volatile organic compounds) may be replaced with hot water to produce the same end products. The water will be heated under high pressure to well above the melting point of the polymer or resin. The solid polymer or resins will be injected in its solid state, to be melted and pulverized by the hot water jet. The provision of multiple ports eliminates the problematic introduction of large solid particles into the high pressure pumps, and requires only standard

operation of the high pressure process pump. Pressure indicator 126 is provided to monitor feed pressure to pump 128. The high pressure process pump 128 is typically a positive displacement pump, e.g., a triplex or intensifier pump. From process pump 128 the product flows at high pressure through line 130 into coil 132 where pressure fluctuations generated by the action of pump 128 are regulated by expansion and contraction of coil tubing. It may be desirable or necessary to heat or cool the feed stock. Heating system 148 may circulate hot fluid in shell 154 via lines 150 and 152, or cooling system 156 may be used. The heating medium may be hot oil or steam with the appropriate means to control the temperature and flow of the hot fluid such that the desired product temperature is attained upon exiting coil 132. The product exits coil 132 through line 134, where pressure indicator 136 and temperature indicator 138 monitor these parameters. Line 134 splits into lines 134A and 134B to lead the product into double-jet cell 140 from both ends, such that each of the two nozzles in cell 140 is supplied with product at high pressure, for example a pressure of 15,000 psi.

Processing of the product components, e.g., to form a colloid system, takes place in double-jet cell 140 where the feed stock is forced through two jet generating orifices and through an absorption cell wherein the jets are forced to flow in close proximity and in essentially opposite directions, thereby causing the jets' kinetic energy to be absorbed by the fluid streams. In each of the treatment stages (there may be one or more), intense forces of shear, impact, and/or cavitation break down the oil phase into extremely small and highly uniform droplets, and allow sufficient time for an emulsifier to interact with these small oil droplets to stabilize the emulsion. Before exiting the absorption cell, the

to reduce the number of separate feed lines, or there may be as many feed lines as product components.

Water from tank 118 flows through line 120 and valve 122, by means of transfer pump 124 to the H.P. pump 128. Elements 128 through 138 and 148 through 158 have similar functions to the same numbered elements of the system of FIG. 1.

Oil and emulsifier, each representing a possibly unlimited number and variety of components which may be introduced separately, flow from sources 112 and 114 into double-jet cell 140 through lines 162 and 164, each line having a pressure indicator 170 and 172 and a temperature indicator 174 and 176, by means of metering pumps 166 and 168. Metering pumps 166 and 168 are suitable for the type of product pumped (e.g. sanitary cream, injectable suspension, abrasive slurry) and the required flow and pressure ranges. For example, in small scale systems peristaltic pumps are used, while in production system and/or for high pressure injection, diaphragm or gear pumps are used.

Inside double-jet cell 140 the water is forced through two orifices creating two water jets. Other product components, as exemplified by the oil and emulsifier, are injected into double-jet cell 140. The interaction between the extremely high velocity water jet at one end of double-jet cell 140 and the stagnant components from lines 162 and 164 subjects the product to a series of treatment stages. In each stage intense forces of shear, impact, and/or cavitation break down the oil and emulsifier to extremely small and highly uniform droplets, and allows sufficient time for the emulsifier to interact with the oil droplets. After the interaction between the water jet at one end of double-jet cell 140 and the components from lines 162 and 164, the processed mixture meets the second water jet of the other end of

pumped and the required flow and pressure ranges. For solids that should be introduced in dry powder form, compressed gas 214 is supplied. Compressed gas (such as air or Nitrogen) from source 214 flows through line 262 and is regulated by regulator 270. Gas flow into the feed tank discharge line 201 facilitates and regulates the flow of powder into double-jet cell 140.

Inside double-jet cell 140 the liquid phase is forced through two dissimilar orifices, creating two dissimilar jets. The orifices are dissimilar in such a way to create a vacuum in one end of the cell and positive pressure in the other end. For example, one orifice is made larger then the other. The jet from the larger orifice creates a vacuum before entering the absorption cell and creates positive pressure at the other end of the absorption cell. The solid phase is injected into double-jet cell 140 at a point where the liquid jet has generated the vacuum.

The interaction between the extremely high velocity liquid jet at one end of double-jet cell 140 and the stagnant solids line 201 subjects the product to a series of treatment stages. In each stage intense forces of shear, impact, and/or cavitation break down the solids to extremely small and highly uniform particles (or droplets if in melted form), and allows sufficient time for the emulsifier to interact with the solids particles and/or droplets. After the interaction between the first liquid jet at one end of double-jet cell 140 and the solids from line 201, the processed mixture meets the second liquid jet from the other end of double-jet cell 140. The second liquid jet generates additional intense forces of shear, impact, and/or cavitation to further reduce the size of solid particles/droplets and increase their uniformity. The second liquid jet also carries some of the processed product back into the absorption

of an abrasion resistant material such as ceramic or stainless steel depending on product abrasiveness and the reactor lumen inner diameter (e.g. 0.02 inch to 0.12 inch). Seals 15 are made of plastic unless the process requires elevated temperature, in which case other materials such as stainless steel may be used. Upon fastening simultaneously bodies 11 at the two ends of double-jet cell 140, the series of reactors 14 and seals 15 form a pressure containing absorption cell. Ports 27 and 28 are standard 1/4" M/P (e.g. Autoclave Engineers #F250). The function of ports 27 and 28 varies depending on the system configuration (FIGS. 1 through 3).

In the type of system shown in FIG. 1, port 27 functions as the discharge port of double-jet cell 140 while port 28 is plugged. Pre-mixed components are fed into the double-jet cell through ports 20 at both ends of the double-jet cell, flow through round openings 21 (e.g. 1/8" dia. hole), and flow through round openings 22 (e.g. 1/16" dia. hole). The product liquid is then forced by high pressure through orifice 23. The diameter of orifice 23 determines the maximum attainable pressure for any given flow rate. For example, a 0.015 in. dia. hole will enable 10,000 psi with a flow rate of 1 liter/min. of water. More viscous fluids require an orifice opening as large as 0.032 in. dia. to attain the same pressure and flow rate, while smaller systems with pump capacity under 1 liter/min. require an orifice as small as 0.005 in dia. to attain 10,000 psi. The high velocity jet is ejected from orifice 23 into opening 24 (e.g. 1/16" dia. hole) in nozzle 13 and then into opening 25 (e.g. 3/32" dia. hole) in body 11. Opening 25 in body 11 communicates with round opening 26 (e.g. 3/32" dia.) in body 11. Processing of the product begins in orifices 23 at both ends of the double-jet cell, where the product is accelerated to a velocity exceeding 500 ft/sec. upon

shear or cavitation. Smaller reactor inner diameters with turbulent flow may be used to effect intense shear, repeated stages of cavitation, and impact through repeated interaction. The process may be made gradual or with several stages of increasing or decreasing process intensity by assembling various sizes of reactors 14 and seals 15. Process duration may be easily determined by the number of reactors 15. Retainer 12 is made with male and female threads of the same size. This enables connecting one, two, or three retainers (not shown) in a single dual-jet cell assembly which in turn enables use of different numbers of reactors (e.g., one to twenty).

In the type of system shown in FIG. 2, port 27 functions as inlet port for the oil phase, while port 28 functions as the discharge port of double-jet cell 140. Water phase is fed into the double-jet cell 140 through ports 20 at both ends of cell 140 and is forced by high pressure through orifices 23 in a manner similar to the one used in the system of FIG. 4.

Referring now to FIG. 7, in the system shown in FIG. 2, jet stream 50 is maintained essentially unchanged as it flows through openings 24 in one end of the double-jet cell while jet 51 is maintained essentially unchanged as it flows through openings 28 in the other end of the double-jet cell. Jet 50 is made more intense than jet 51 by using a larger orifice to generate jet 50 than to generate jet 51. Since both ends of double-jet cell 140 are subjected to the same pressure, the flow rate through the larger orifice is higher then through the smaller orifice. The two jet streams 50 and 51 impact each other in cavity 32 and form a coherent flow stream 53. Because jet 50 is more intense than jet 51, coherent stream 53 exits the double-jet cell through opening 30 and port 28. Because jet 50 flows uninterrupted and at a very high velocity through opening

jet 51, enable particle size reduction of extremely hard materials such as ceramic and carbide powders.

Other embodiments are within the scope of the following claims.

What is claimed is:

10. A method of processing product components, comprising:

directing a first jet of fluid from a common fluid source along a first path,

directing a second jet of fluid from the common fluid source along a second path, the paths oriented essentially opposite one another to cause interaction between the jets that forms a cylindrical stream surrounding one of the jets.

11. A method of processing product components comprising:

directing a first jet of fluid along a first path;

directing a second jet of fluid along a second path; and

causing sheer and cavitation in a third fluid by positioning the fluid between the jets.

12. The method of claim 11, wherein the paths are oriented in essentially opposite directions.

13. The method of claim 11, further comprising forming a stream oriented essentially opposite to one of the jets.

14. The method of claim 11, further comprising forming the jets of fluid from a common fluid source.

15. The method of claim 11, wherein the third fluid includes solids.

16. The method of claim 15, wherein solids comprise at least one of the following: powders, granules, and slurries.

22. The apparatus of claim 21, further comprising an outlet port configured to emit the stream.

23. The apparatus of claim 21, wherein the nozzles are aligned essentially opposite one another.

24. The apparatus of claim 21, further comprising an inlet port configured for receiving a second fluid, the inlet port aligned to position the received second fluid such that the jets cause sheer and cavitation in the second fluid.

25. The apparatus of claim 21, further comprising a port that may be configured to be either an inlet port or an outlet port.

26. The apparatus of claim 21, wherein the chamber comprises at least one reactor.

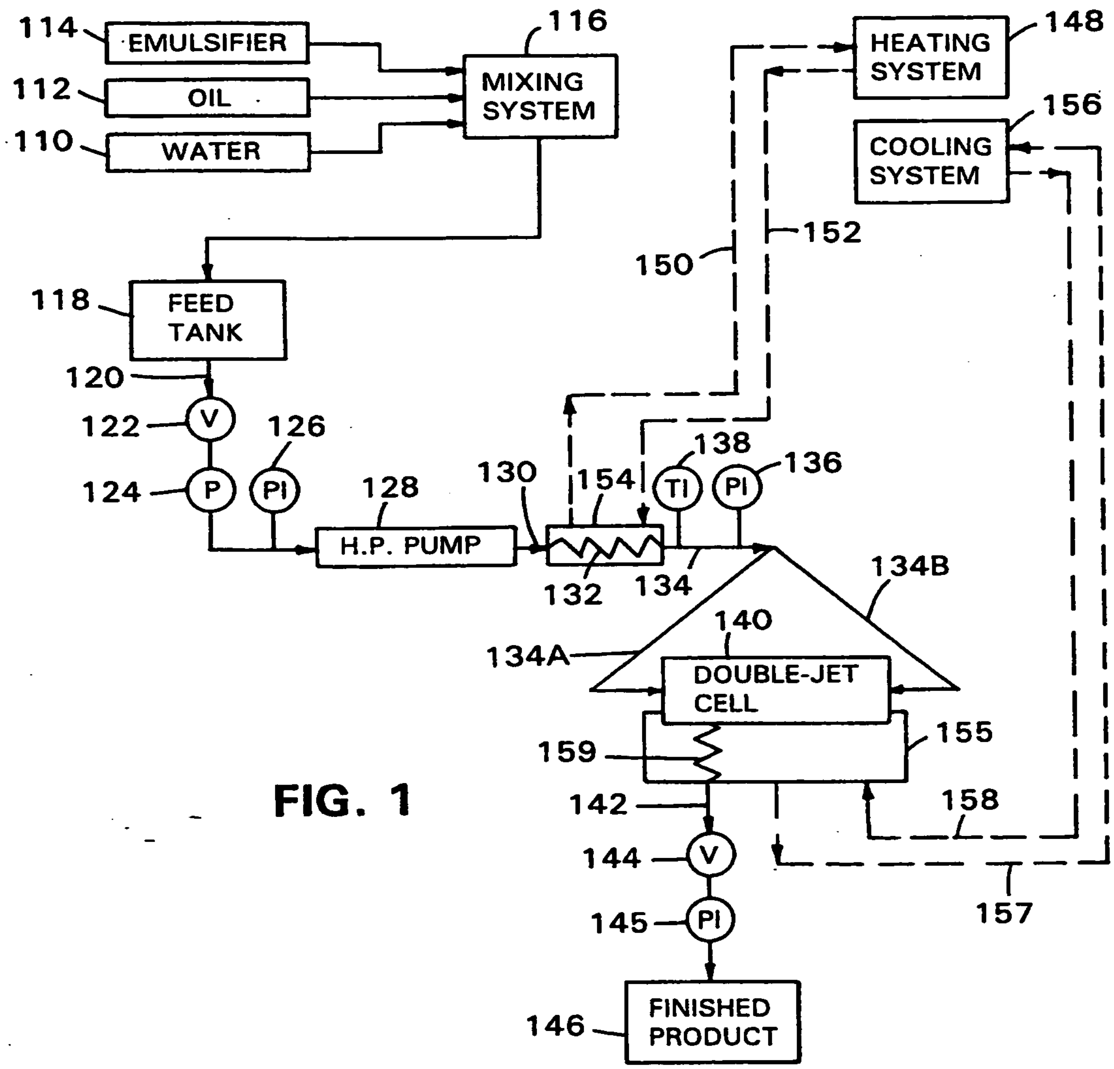
27. The apparatus of claim 26, wherein the reactors are interchangeable with other reactors having a different reactor characteristic.

28. The apparatus of claim 27, wherein the reactor characteristic comprises reactor inner diameter.

29. The apparatus of claim 27, wherein the reactor characteristic comprises reactor contour.

30. The apparatus of claim 27, wherein a reactor characteristic comprises reactor material composition.

31. The apparatus of claim 26, further comprising at least one seal positioned between reactors.



114
EMULSIFIER
112
OIL
110
WATER
116
MIXING SYSTEM
118
FEED TANK
120
122
V
126
124
P
PI
128
H.P. PUMP
130
154
138
TI
PI
136
132
134
134B
140
134A
DOUBLE-JET CELL
155
159
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FINISHED PRODUCT
148
HEATING SYSTEM
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COOLING SYSTEM
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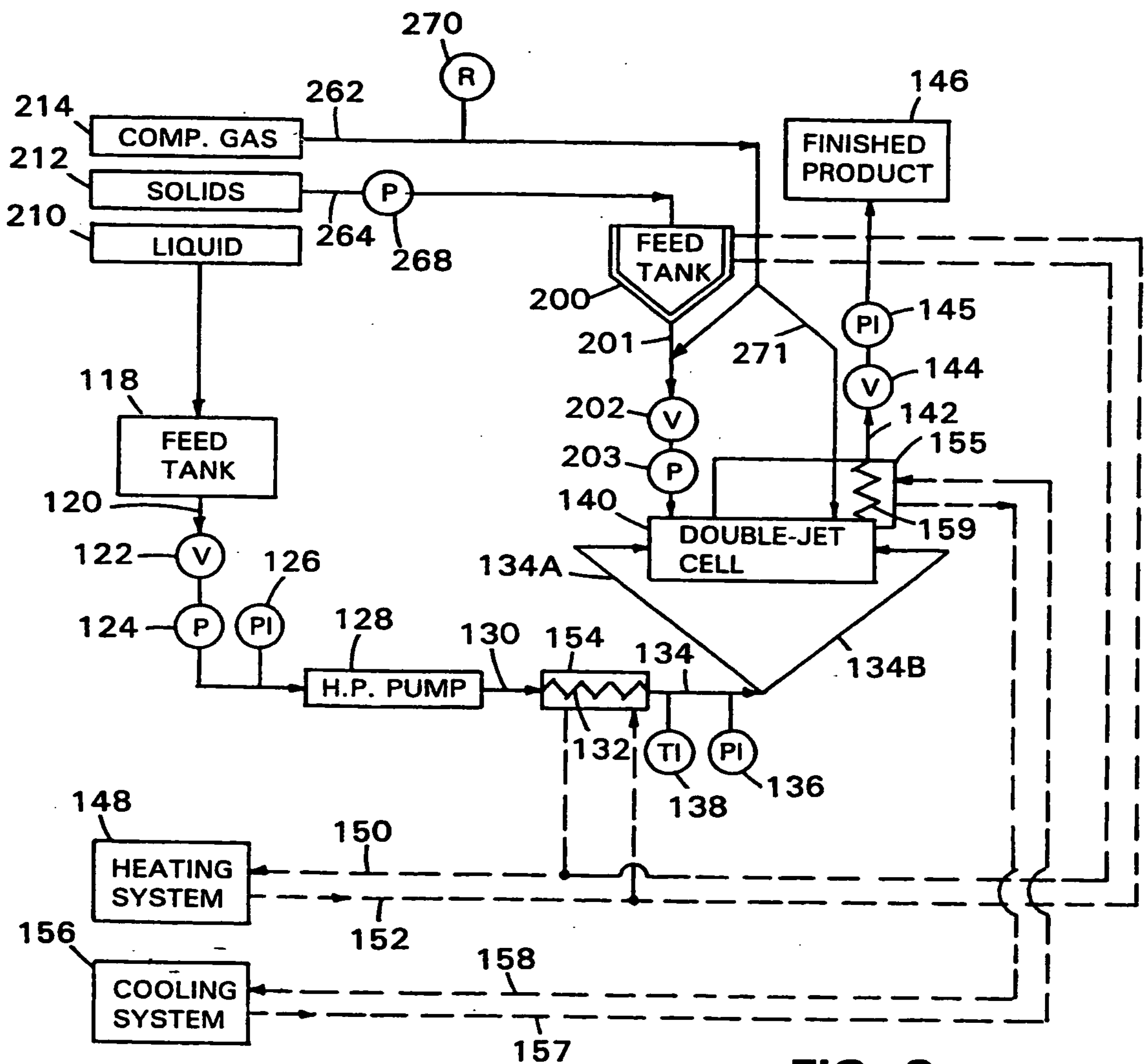
157

FIG. 1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COOLING SYSTEM
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FIG. 3

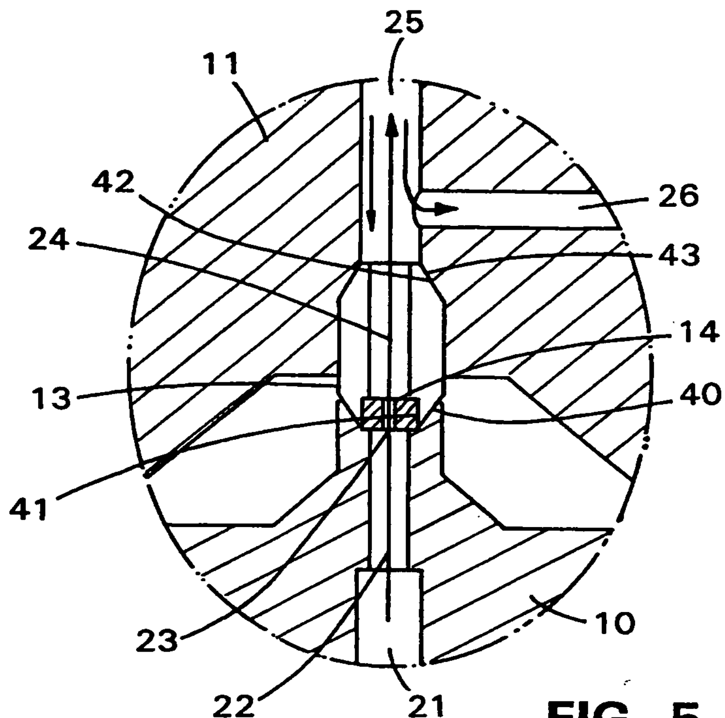

FIG. 5